

Publication number: JP8159864 (A)

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Classification:

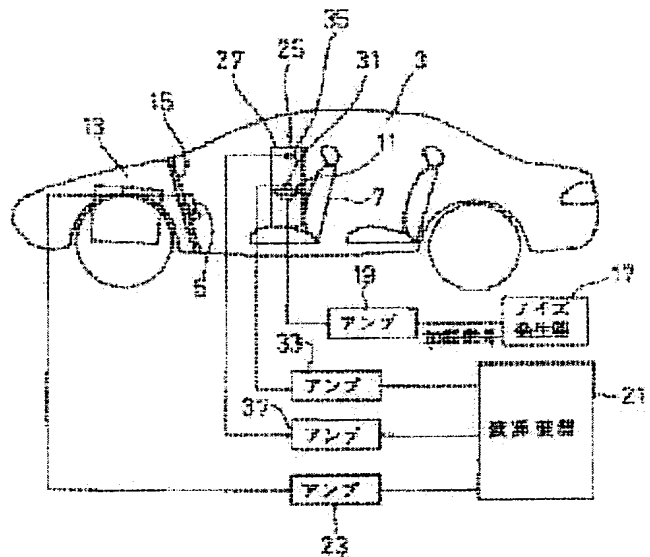
- international: **G01H17/00; G01H17/00; (IPC1-7): G01H17/00**

- European:

Application number: JP19940303499 19941207

Priority number(s): JP19940303499 19941207

PURPOSE: To easily and precisely measure acoustic characteristics in a vehicle cabin without working the cabin. **CONSTITUTION:** The acoustic characteristics measuring apparatus to measure the acoustic characteristics in which a sound source 25 is composed by attaching a speaker unit 11 to the inside of an enclosure 27 and at the same time, forming an opening to make sound propagate through the space and the sound source 25 is so installed as to position the opening at an auditory point in the space and by which the acoustic characteristics between the auditory point and the sound pressure detecting means 5 is measured, has a characteristic that oscillation force measuring means 21 (arithmetic unit), 31, 35 to measure or estimate the oscillation force of the sound source 25 and an acoustic characteristic measuring means 21 (arithmetic unit); to measure the acoustic characteristics between the auditory point and the sound pressure detecting means 5.



Machine translation JP08159864

(Bibliographic data + Summary + Claim)

(19)**Publication country**Japan Patent Office (JP)
(12)**Kind of official gazette**Publication of patent applications (A)
(11)**Publication No.**JP,8-159864,A
(43)**Date of Publication**June 21, Heisei 8 (1996)
(54)**Title of the Invention**Acoustic feature measuring device
(51)**International Patent Classification (6th Edition)**

G01H 17/00 C

Request for ExaminationUnrequested**The number of claims** 7**Mode of Application**OL**Number of Pages**10(21)**Application number**Japanese Patent Application No. 6-303499(22)**Filing date**December 7, Heisei 6 (1994)(71)**Applicant****Identification Number**000003997**Name**Nissan Motor Co., Ltd.**Address**2, Takara-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken(72)**Inventor(s)****Name**Tomoyuki Matsuzawa**Address**2, Takara-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken Inside of Nissan Motor Co., Ltd.(72)**Inventor(s)****Name**Maruyama Shin-ichi**Address**2, Takara-cho, Kanagawa-ku, Yokohama-shi, Kanagawa-ken Inside of Nissan Motor Co., Ltd.(74)**Attorney****Patent Attorney****Name**Miyoshi Hidekazu (besides eight persons)

(57) Abstract

Objects of the InventionIt makes it possible to measure easily and correctly the acoustic feature of the vehicle interior of a room etc., without carrying out the processing maneuvers of the vehicle room etc.

Elements of the InventionIt comprises:

Attach the loudspeaker unit 11 to an inside of the enclosure 27, and. The openings 47a and 47b which a sound leaves to space in this enclosure 27 are formed, the sound source 25 is constituted, the sound source 25 is arranged so that said openings 47a and 47b may be located in a listening point of said space, the sound pressure detecting means 5 is arranged at a point with space, and it is a listening point.

In an acoustic feature device which measures an acoustic feature between the sound pressure detecting means 5, The acoustic feature measuring means 21 which has the exciting-force measuring means 21, 31, and 35 which measure or presume exciting force of the sound source 25 in said listening point whenever the sound source 25 drives, and measures an acoustic feature between a listening point and the sound pressure detecting means 5 based on exciting force and an output signal of the sound pressure detecting means 5.

Claim(s)

Claim 1An acoustic feature measuring device comprising:

Attach a loudspeaker unit to an inside of enclosure, and to this enclosure. Provide an opening

which a sound leaves to space and constitute a sound source, and said sound source is arranged so that said opening may be located in a listening point of said space, An exciting-force measuring means which measures or presumes exciting force of a sound source in said listening point in an acoustic feature measuring device which arranges a sound pressure detecting means at a point with said space, and measures an acoustic feature between said listening point and a sound pressure detecting means whenever said sound source drives. An acoustic feature measuring means which measures an acoustic feature between said listening point and a sound pressure detecting means based on said exciting force and an output signal of said sound pressure detecting means.

Claim 2The acoustic feature measuring device comprising according to claim 1:

Said exciting-force measuring means is a speaker cone vibration detecting means of said loudspeaker unit.

A sound pressure detecting means in said listening point.

An arithmetic unit which calculates said exciting force based on an output signal of said speaker cone vibration detecting means and a sound pressure detecting means in said listening point.

Claim 3The acoustic feature measuring device comprising according to claim 1:

Said exciting-force measuring means is an input detecting means to said loudspeaker unit.

A sound pressure detecting means in said listening point.

An arithmetic unit which calculates said exciting force based on an output signal of an input detecting means to said loudspeaker unit, and a sound pressure detecting means in said listening point.

Claim 4The acoustic feature measuring device comprising according to claim 1:

Two or more sound pressure detecting means which can set said exciting-force measuring means near **said** the listening point.

An arithmetic unit which calculates said exciting force based on an output signal of two or more sound pressure detecting means which can be set near **said** the listening point.

Claim 5An acoustic feature measuring device, wherein it is the acoustic feature measuring device according to any one of claims 1 to 4, said enclosure has the shape of human being's head and a thorax and said opening is located in a handle part.

Claim 6An acoustic feature measuring device, wherein it is the acoustic feature measuring device according to claim 5, a sound pressure detecting means of said listening point is provided in said opening and said loudspeaker unit is provided in said thorax.

Claim 7An acoustic feature measuring device being the acoustic feature measuring device according to any one of claims 1 to 6, having formed said enclosure on a sheet of the automobile vehicle interior of a room, and providing a sound pressure detecting means arranged to said space in a dash panel of the automobile vehicle interior of a room.

Detailed Description of the Invention

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Industrial ApplicationThis invention relates to the acoustic feature measuring device which measures a sound transfer characteristic indoor **narrow** like a vehicle room.

0002

Description of the Prior ArtAs this conventional kind of an acoustic feature measuring device, there is a thing as shown, for example in drawing 8 (refer to JP,54-71675,A).

0003That is, this acoustic feature measuring device has arranged the simple point sound source 1 to the listening point of the space of vehicle room 3 grade, has arranged the microphone 5 at the point equivalent to the sound source of vehicle room 3 grade, and has measured the acoustic feature for the two above-mentioned points. That is, the simple point sound source 1 is installed on the sheet 7 in the vehicle room 3, and has structure which attached to the point of the loudspeaker 11 the phon 9 which filled up the inside with the sound damping material. This is for making it reciprocity materialized approximately, even if the impedance of the simple point sound source 1 is raised, change of the volume velocity in a listening point is lessened even if the surrounding acoustic field changes as a result, and it uses an acoustic feature in the form of sound pressure / loudspeaker input voltage. Said microphone 5 is attached to the dash panel 15 which divides the engine room 13 and the vehicle room 3.

And the signal from the noise source 17 is inputted into said loudspeaker 11 via the amplifier 19. Loudspeaker input voltage is inputted into the arithmetic unit 21. The detecting signal of said microphone 5 is inputted into the arithmetic unit 21 via the amplifier 23.

0004Therefore, the signal from the noise source 17 is inputted into the loudspeaker 11 via the amplifier 19, and the emitted sound is detected with the microphone 5. The detecting signal of the microphone 5 is inputted into the arithmetic unit 21 via the amplifier 23. Therefore, the reciprocity theorem in an acoustic field can be applied, the acoustic feature for said two points can be expressed with the form of sound pressure / loudspeaker input voltage, and the acoustic feature of the vehicle interior of a room etc. can be measured easily and correctly, without processing and maneuvering a vehicle room etc.

0005

Problem(s) to be Solved by the InventionHowever, since what it is not necessarily asking for the volume velocity of the air of the point equivalent to listening points, such as a vehicle room, in the above devices, and can ask for is sound pressure / loudspeaker input voltage, The characteristic of volume velocity / loudspeaker input voltage will also be contained, the frequency characteristic of sound pressure/volume velocity and difference showing a actual acoustic feature arise, and there is a problem that the form of an exact frequency characteristic is not searched for.

0006Then, this invention aims at offer of the acoustic feature measuring device which can measure a more exact acoustic feature easily.

0007

Means for Solving the ProblemIn order to solve an aforementioned problem, an invention of claim 1, Attach a loudspeaker unit to an inside of enclosure, and to this enclosure. Provide an opening which a sound leaves to space and constitute a sound source, and said sound source is arranged so that said opening may be located in a listening point of said space, In an acoustic feature control device which arranges a sound pressure detecting means at a point with said space, and measures an acoustic feature between said listening point and a sound pressure detecting means, Whenever said sound source drives, it has an exciting-force measuring means which measures or presumes exciting force of a sound source in said listening point, and an acoustic feature measuring means which measures an acoustic feature between said listening point and a sound pressure detecting means based on said exciting force and an output signal of said sound pressure detecting means was established.

0008An invention of claim 2 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means, It has a speaker cone vibration detecting means of said loudspeaker unit, and a sound pressure detecting means in said listening point, and consists of an arithmetic unit which calculates said exciting force based on an output signal of said speaker cone vibration detecting means and a sound pressure detecting means in said listening point.

0009An invention of claim 3 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means, It has an input detecting means to said loudspeaker unit, and a sound pressure detecting means in said listening point, and consists of an arithmetic unit which calculates said exciting force based on an output signal of an input detecting means to said loudspeaker unit, and a sound pressure detecting means in said listening point.

0010An invention of claim 4 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means consists of an arithmetic unit which calculates said exciting force based on an output signal of two or more sound pressure detecting means which can be set near **said** the listening point, and two or more sound pressure detecting means which can be set near **said** the listening point.

0011An invention of claim 5 is the acoustic feature measuring device according to any one of claims 1 to 4, said enclosure has the shape of human being's head and a thorax, and said opening is located in a handle part.

0012An invention of claim 6 is the acoustic feature measuring device according to claim 5, a sound pressure detecting means of said listening point is provided in said opening, and said loudspeaker unit is provided in said thorax.

0013An invention of claim 7 is the acoustic feature measuring device according to any one of claims 1 to 6, formed said enclosure on a sheet of the automobile vehicle interior of a room, and provided a sound pressure detecting means arranged to said space in a dash panel of the automobile vehicle interior of a room.

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FunctionAccording to the invention of claim 1 of the above-mentioned means, if a loudspeaker unit has an input signal, the sound emitted from the loudspeaker unit will go away from the

opening of the enclosure in a listening point to space. The sound which came out to space is detected by the sound pressure detecting means arranged at the point with space. And an exciting-force measuring means measures or presumes the exciting force of the sound source in a listening point. And based on said exciting force and the output signal of a sound pressure detecting means, an acoustic feature measuring means measures the acoustic feature between a listening point and a sound pressure detecting means.

0015In addition to an operation of an invention of claim 1, in the invention of claim 2, a speaker cone vibration detecting means detects vibration of a loudspeaker unit. The sound pressure detecting means in a listening point detects the sound pressure in a listening point. And the exciting force of a loudspeaker unit can be calculated based on the output signal of a speaker cone vibration detecting means and the sound pressure detecting means in a listening point. Therefore, it can ask for the volume velocity of the air in the sound pressure detecting means in a listening point from the calculated exciting force and the detecting signal of the sound pressure detecting means in a listening point. From this volume velocity and the detecting signal of the sound pressure detecting means of a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity.

0016In the invention of claim 3, an input detecting means can detect the input to a loudspeaker unit, a sound pressure detecting means can detect the sound pressure in a listening point, and exciting force can be calculated based on the output signal of a loudspeaker input detecting means and the sound pressure detecting means in a listening point. For this reason, it can ask for the volume velocity in a loudspeaker unit based on the calculated exciting force and the detecting signal of the sound pressure detecting means in a listening point. For this reason, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

0017In addition to an operation of an invention of claim 1, in the invention of claim 4, two or more sound pressure detecting means which can set the sound pressure in a listening point near the listening point detect. And the exciting force of a loudspeaker unit can be calculated based on the output signal of two or more of these sound pressure detecting means. It can ask for the volume velocity of the air in a listening point with this calculated exciting force and sound pressure / **near / which was detected by two or more sound pressure detecting means / the listening point** . Therefore, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

0018In the invention of claim 5, since the enclosure has the shape of human being's head and a thorax in addition to the operation of an invention of claim 1-4, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured.

0019In addition to an operation of an invention of claim 5, in the invention of claim 6, the sound pressure detecting means in a listening point can detect the sound pressure in the opening located in a handle part. Therefore, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured.

0020In addition to an operation of an invention of claim 1-6, in the invention of claim 7, the acoustic feature between dash panels with the input of the noise from the listening point and engine room on the sheet of the automobile vehicle interior of a room can be outputted in the form of sound pressure/volume velocity.

0021

ExampleHereafter, the example of this invention is described. A same sign is given to drawing 8 and an identical configuration portion, it explains and the duplicate explanation is omitted.

0022Drawing 1 is a block diagram concerning the 1st example of this invention. And also in the 1st example of this invention, it has said simple point sound source 1 (drawing 8) and the same sound source 25. Although the sound source 25 is mentioned later in detail, the loudspeaker unit 11 is attached in general in the enclosure 27. The acceleration sensor 31 as a speaker cone vibration detecting means is formed in the vibration portion of the loudspeaker unit 11. The acceleration sensor 31 is connected to the arithmetic unit 21 as an acoustic feature measuring means via the amplifier 33. The microphone 35 as a sound pressure detecting means in a listening point is formed in the listening point position of the enclosure 27. The microphone 35 is connected to the arithmetic unit 21 via the amplifier 37. And said arithmetic unit 21, said acceleration sensor 31, and the microphone 35 constitute the exciting-force measuring means which measures or presumes the exciting force in a listening point in this example.

0023The details of said sound source 25 have become like drawing 2. First, the enclosure 27 is formed in the rectangle cube in the air. The bridge walls 39a, 39b, 41a, and 41b in every direction are formed in the inside of the enclosure 27. The two loudspeaker units 11 are formed in the lateral partition walls 41a and 41b. The breakthroughs 43a and 43b are formed in the top both sides of the enclosure 27. Fit fixing of the short pipes 45a and 45b is carried out to the breakthroughs 43a and 43b. The sound constitutes the openings 47a and 47b left to space from the enclosure 27 with these short pipes 45a and 45b. When the enclosure 27 is laid to the sheet 7 as mentioned above, the openings 47a and 47b are constituted so that it may become a listening point of a crew member's ear position. Said microphone 35 is formed in the length direction central lower part of said short pipes 45a and 45b, respectively. Said loudspeaker unit 11 is being fixed to said lateral partition walls 41a and 41b, respectively. Said acceleration sensor 31 is attached to each loudspeaker unit 11, respectively. And the space 49a-49d in said enclosure 27 is filled up with the sound-absorbing materials 51a-51d.

0024Next, if the vibration applying signal from the noise source 17 is inputted into the loudspeaker unit 11 via the amplifier 19, the loudspeaker unit 11 will change a vibration applying signal into a sound, will leave this sound into the vehicle room 3 as space from the openings 47a and 47b of each short pipes 45a and 45b, and will excite the inside of the vehicle room 3. The acceleration signal of the vibration portion of the loudspeaker unit 11 at this time is detected by the acceleration sensor 31, and is inputted into the arithmetic unit 21 via the amplifier 33. The sound pressure of the sound which comes out of the openings 47a and 47b of the short pipes 45a and 45b is detected with the microphone 35, and is inputted into the arithmetic unit 21 via the amplifier 37. The sound which excited the inside of the vehicle room 3 reaches the microphone 5 of the dash panel 15, the sound pressure is detected, and the arithmetic unit 21 is inputted via the amplifier 23. And the arithmetic unit 21 calculates the exciting force of the listening point which is equivalent to an ear position using the acceleration signal from the acceleration sensor 31, and the signal (sound pressure) from the microphone 35. It asks for the volume velocity of the air of a listening point using this exciting force and the signal (sound pressure) from the microphone 35. furthermore -- using the signal from the microphone 5 of this volume velocity and the dash panel 15 -- a listening point and the dash panel 15 -- if it puts in another way, the acoustic feature between the microphone 35 and the microphone 5 can be searched for in the form of sound pressure/volume velocity.

0025Here, the volume velocity of the air of the point equivalent to an ear position is called for as follows. (1) type will be materialized if sound pressure in loudspeaker unit 11 vibration portion, sound pressure in / respectively / for volume velocity / the position of P_A , V_A , and the microphone 35, and volume velocity are made into P_B and V_B , respectively.

Equation 1

For drawings please refer to the original document.

Here, a, b, c, and d are values decided by shape between the loudspeaker unit 11 and the microphone 35. In this example, since the shape between the loudspeaker unit 11 and the microphone 35 does not change, it serves as a constant.

0026(1) As for the value of V_A , in a formula, the acceleration from the acceleration sensor 31 and the value of P_B are calculated for the value of P_A using the sound pressure from the microphone 35 from the voltage to a loudspeaker. Therefore, if (1) type is used, it can ask for volume velocity V_B of the air of the point equivalent to an ear position.

0027Thus, since an acoustic feature can be searched for in the form of sound pressure/volume velocity by asking for the volume velocity in a listening point in the 1st example of this invention, It is lost that the characteristic of volume velocity / loudspeaker input voltage is contained like before, and the form of an exact frequency characteristic can be searched for in accordance with the frequency characteristic of the sound pressure/volume velocity showing a actual acoustic feature.

0028Since it can ask for the volume velocity in an exciting point even if the surrounding acoustic field changes whenever it performs such processing, an acoustic feature can be searched for in the form of sound pressure/volume velocity, and measurement of an exact frequency characteristic can be realized.

0029Drawing 3 shows the block diagram concerning the 2nd example of this invention. In this example, a same sign is given to the above-mentioned example and an identical configuration

portion, it explains and the duplicate explanation is omitted.

0030In this example, it differs from the 1st example in that exciting force is searched for from the input voltage of the loudspeaker unit 11, and the sound pressure of the microphone 35. Therefore, in this 2nd example, an acceleration detector is not formed in the loudspeaker unit 11, but the vibration applying signal to the loudspeaker unit 11 is inputted into the arithmetic unit 21. Namely, the arithmetic unit 21 constitutes the input detecting means to the loudspeaker unit 11 from this 2nd example, The arithmetic unit 21 as this input detecting means and the microphone 35 as a sound pressure detecting means in a listening point constitute the exciting-force measuring means which measures or presumes the exciting force of the sound source in a listening point. And the exciting force of the sound source in a listening point can be measured from the input voltage of the loudspeaker unit 11, and the sound pressure detected with the microphone 35, and it can ask for the volume velocity in a listening point with the arithmetic unit 21 from this exciting force and the sound pressure detected with the microphone 35. The acoustic feature between the microphones 5 and 35 can be outputted in the form of sound pressure/volume velocity from this volume velocity and the sound pressure which said microphone 5 detected. Therefore, in this example, the same operation effect as the 1st example is done so, and also it is not necessary to form an acceleration sensor and a cost cut can be aimed at.

0031Drawing 4 and drawing 5 show the 3rd example of this invention. This example is an example which the enclosure transformed. In this example, the two microphones 35a and 35b are approached and attached to the short pipes 45a and 45b, respectively. Therefore, it has composition provided with two or more sound pressure detecting means near the listening point. And the exciting force of the sound source in a listening point can be searched for with the arithmetic unit 21 from the sound pressure detected with two or more of these microphones 35a and 35b. It can ask for the volume velocity of the air in a listening point with this exciting force and the sound pressure detected with the microphones 35a and 35b. The acoustic feature between the microphone 5 and the microphone 35 can be outputted in the form of sound pressure/volume velocity using this volume velocity and the sound pressure signal detected with the microphone 5.

0032Here, the volume velocity of the air of the point equivalent to an ear position is called for as follows. If the imaginary part of a cross spectrum **in / the distance of the two microphones 35a and 35b which approached can be kept from r , and / for the density of air / ρ and the two contiguity microphones 35a and 35b** is made into $I_m G_{AB}$ and angular frequency is set to ω , the intensity I in all the zones will become like (2) types.
Equation 2

For drawings please refer to the original document.

I can be written also like (3) types.

$I = PU$ (3)

Here, P is sound pressure and U is particle velocity.

0033(2) The volume velocity V of air becomes like (4) types using a formula and (3) types.
Equation 3

For drawings please refer to the original document.

However, the cross-section area of a particle diameter way **in / in S / the microphones 35a and 35b**, P_A , and P_B are the detected sound pressure of the two seasonal microphones 35a and 35b.

0034It can ask for the volume velocity of the air of the listening point which is equivalent to an ear position using the two contiguity microphones 35a and 35b as mentioned above.

0035Therefore, the almost same operation effect as the 1st example is done so also in this 3rd example, and also it can ask for exciting force and volume velocity with the signal of the microphones 35a and 35b in a listening point, and a more exact output is attained.

0036Drawing 6 shows the 4th example of this invention. This 4th example shows the modification of the enclosure. The enclosure 53 of this drawing 6 is equivalent to the enclosure 27 of the 1st example of said drawing 2.

Fundamental composition is the same.

However, in the example of this drawing 6, the enclosure 53 has the shape of human being's head 53a and the thorax 53b. And the opening 47a (47b) is located in the handle part 53c of the head 53a. Therefore, in this example, since the almost same operation effect as the 1st example is done so and also the enclosure 53 is carrying out shape of human being's head and a thorax, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured. The loudspeaker unit 11 can be attached that there is no unreasonableness in a thorax. In this 2nd example, the input voltage of the loudspeaker unit 11 can be used instead of the acceleration sensor 31, and it can also ask for the volume velocity of the air in an ear position.

0037 Drawing 7 shows the 5th example of this invention. This example also shows the modification of the enclosure. The enclosure 55 of this drawing 7 is equivalent to the enclosure 27 of the 3rd example of said drawing 5. And the enclosure 55 has the forms of the head 55a and the thorax 55b. Therefore, the same operation effect as said 3rd example can be done so, and also there is an advantage that the acoustic feature which took into consideration human being's head-related transfer function and the characteristic of the ear like the 4th example can be measured.

0038 Although each above-mentioned example explained the case where the acoustic feature between a dash panel and the driver's seat ear position of the car interior of a room was measured, it is also possible to apply to measuring applied objects other than this, for example, the acoustic feature between the loudspeaker of an audio and a seat ear position. It is also possible to apply to applied objects other than vehicles, for example, a marine vessel, an airplane, or a house.

0039

Effect of the Invention As mentioned above, according to the invention of claim 1, by an exciting-force measuring means, the exciting force of the sound source of a listening point can be measured, and the acoustic feature between a listening point and a sound pressure detecting means can be measured based on this exciting force and the output signal of the sound pressure detecting means of a point with space so that clearly. That is, it can ask for the volume velocity in a listening point based on exciting force, and the acoustic feature between a listening point and a sound pressure detecting means can be outputted by the relation between sound pressure/volume velocity with the output signal of this volume velocity and sound pressure detecting means. Therefore, since it always asks for the volume velocity in an exciting point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

0040 In the invention of claim 2, the exciting force of the sound source in a listening point can be measured or presumed by the speaker cone vibration detecting means of a loudspeaker unit, and the sound pressure detecting means in a listening point. And it can ask for the volume velocity of a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. Based on this volume velocity and the output signal of the sound pressure detecting means of a point with space, the acoustic feature between a listening point and a point with space can be correctly searched for in the form of sound pressure/volume velocity. Therefore, since it can always ask for the volume velocity in an exciting point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

0041 In the invention of claim 3, the exciting force in a listening point can be measured or presumed by the input detecting means to a loudspeaker unit, and the sound pressure detecting means in a listening point. And it can ask for the volume velocity of the air in a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. Based on this volume velocity and the detecting signal of the sound pressure detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly. Since the input signal to a loudspeaker unit is used on the occasion of measurement or presumption of exciting force, structure can be easy and it can manufacture cheaply.

0042 In the invention of claim 4, the exciting force of the sound source in a listening point can be searched for based on the output signal of two or more sound pressure detecting means which can be set to a listening point. It can ask for the volume velocity in a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. And based on this volume velocity and the output signal of the sound pressure

detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly. Since exciting force is searched for with the signal of two or more sound pressure detecting means in a listening point, a more exact acoustic feature can be outputted.

0043In the invention of claim 5, in addition to one effect of the invention of claims 1-4, an acoustic feature can be measured in consideration of human being's head-related transfer function or the characteristic of an ear, and a more exact acoustic feature can be measured for human being.

0044In the invention of claim 6, in addition to the effect of the invention of claim 5, the sound pressure detecting means of a listening point can be provided in the opening of a handle part, and an acoustic feature can be outputted more correctly. Setting out of a loudspeaker unit can be performed reasonable by providing a loudspeaker unit in a thorax.

0045In addition to one effect of the invention of claims 1-6, in the invention of claim 7, the acoustic feature between dash panels can be correctly searched for from the sheet of the automobile vehicle interior of a room.

Industrial ApplicationThis invention relates to the acoustic feature measuring device which measures a sound transfer characteristic indoor **narrow** like a vehicle room.

Description of the Prior ArtAs this conventional kind of an acoustic feature measuring device, there is a thing as shown, for example in drawing 8 (refer to JP,54-71675,A).

0003That is, this acoustic feature measuring device has arranged the simple point sound source 1 to the listening point of the space of vehicle room 3 grade, has arranged the microphone 5 at the point equivalent to the sound source of vehicle room 3 grade, and has measured the acoustic feature for the two above-mentioned points. That is, the simple point sound source 1 is installed on the sheet 7 in the vehicle room 3, and has structure which attached to the point of the loudspeaker 11 the phon 9 which filled up the inside with the sound damping material. This is for making it reciprocity materialized approximately, even if the impedance of the simple point sound source 1 is raised, change of the volume velocity in a listening point is lessened even if the surrounding acoustic field changes as a result, and it uses an acoustic feature in the form of sound pressure / loudspeaker input voltage. Said microphone 5 is attached to the dash panel 15 which divides the engine room 13 and the vehicle room 3. And the signal from the noise source 17 is inputted into said loudspeaker 11 via the amplifier 19. Loudspeaker input voltage is inputted into the arithmetic unit 21. The detecting signal of said microphone 5 is inputted into the arithmetic unit 21 via the amplifier 23.

0004Therefore, the signal from the noise source 17 is inputted into the loudspeaker 11 via the amplifier 19, and the emitted sound is detected with the microphone 5. The detecting signal of the microphone 5 is inputted into the arithmetic unit 21 via the amplifier 23. Therefore, the reciprocity theorem in an acoustic field can be applied, the acoustic feature for said two points can be expressed with the form of sound pressure / loudspeaker input voltage, and the acoustic feature of the vehicle interior of a room etc. can be measured easily and correctly, without processing and maneuvering a vehicle room etc.

Effect of the InventionAs mentioned above, according to the invention of claim 1, by an exciting-force measuring means, the exciting force of the sound source of a listening point can be measured, and the acoustic feature between a listening point and a sound pressure detecting means can be measured based on this exciting force and the output signal of the sound pressure detecting means of a point with space so that clearly. That is, it can ask for the volume velocity in a listening point based on exciting force, and the acoustic feature between a listening point and a sound pressure detecting means can be outputted by the relation between sound pressure/volume velocity with the output signal of this volume velocity and sound pressure detecting means. Therefore, since it always asks for the volume velocity in an exciting

point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

0040In the invention of claim 2, the exciting force of the sound source in a listening point can be measured or presumed by the speaker cone vibration detecting means of a loudspeaker unit, and the sound pressure detecting means in a listening point. And it can ask for the volume velocity of a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. Based on this volume velocity and the output signal of the sound pressure detecting means of a point with space, the acoustic feature between a listening point and a point with space can be correctly searched for in the form of sound pressure/volume velocity. Therefore, since it can always ask for the volume velocity in an exciting point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

0041In the invention of claim 3, the exciting force in a listening point can be measured or presumed by the input detecting means to a loudspeaker unit, and the sound pressure detecting means in a listening point. And it can ask for the volume velocity of the air in a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. Based on this volume velocity and the detecting signal of the sound pressure detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly. Since the input signal to a loudspeaker unit is used on the occasion of measurement or presumption of exciting force, structure can be easy and it can manufacture cheaply.

0042In the invention of claim 4, the exciting force of the sound source in a listening point can be searched for based on the output signal of two or more sound pressure detecting means which can be set to a listening point. It can ask for the volume velocity in a listening point based on this exciting force and the output signal of the sound pressure detecting means in a listening point. And based on this volume velocity and the output signal of the sound pressure detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly. Since exciting force is searched for with the signal of two or more sound pressure detecting means in a listening point, a more exact acoustic feature can be outputted.

0043In the invention of claim 5, in addition to one effect of the invention of claims 1-4, an acoustic feature can be measured in consideration of human being's head-related transfer function or the characteristic of an ear, and a more exact acoustic feature can be measured for human being.

0044In the invention of claim 6, in addition to the effect of the invention of claim 5, the sound pressure detecting means of a listening point can be provided in the opening of a handle part, and an acoustic feature can be outputted more correctly. Setting out of a loudspeaker unit can be performed reasonable by providing a loudspeaker unit in a thorax.

0045In addition to one effect of the invention of claims 1-6, in the invention of claim 7, the acoustic feature between dash panels can be correctly searched for from the sheet of the automobile vehicle interior of a room.

FunctionAccording to the invention of claim 1 of the above-mentioned means, if a loudspeaker unit has an input signal, the sound emitted from the loudspeaker unit will go away from the opening of the enclosure in a listening point to space. The sound which came out to space is detected by the sound pressure detecting means arranged at the point with space. And an exciting-force measuring means measures or presumes the exciting force of the sound source in a listening point. And based on said exciting force and the output signal of a sound pressure detecting means, an acoustic feature measuring means measures the acoustic feature between a listening point and a sound pressure detecting means.

0015In addition to an operation of an invention of claim 1, in the invention of claim 2, a speaker cone vibration detecting means detects vibration of a loudspeaker unit. The sound pressure detecting means in a listening point detects the sound pressure in a listening point. And the exciting force of a loudspeaker unit can be calculated based on the output signal of a

speaker cone vibration detecting means and the sound pressure detecting means in a listening point. Therefore, it can ask for the volume velocity of the air in the sound pressure detecting means in a listening point from the calculated exciting force and the detecting signal of the sound pressure detecting means in a listening point. From this volume velocity and the detecting signal of the sound pressure detecting means of a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity.

0016In the invention of claim 3, an input detecting means can detect the input to a loudspeaker unit, a sound pressure detecting means can detect the sound pressure in a listening point, and exciting force can be calculated based on the output signal of a loudspeaker input detecting means and the sound pressure detecting means in a listening point. For this reason, it can ask for the volume velocity in a loudspeaker unit based on the calculated exciting force and the detecting signal of the sound pressure detecting means in a listening point. For this reason, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

0017In addition to an operation of an invention of claim 1, in the invention of claim 4, two or more sound pressure detecting means which can set the sound pressure in a listening point near the listening point detect. And the exciting force of a loudspeaker unit can be calculated based on the output signal of two or more of these sound pressure detecting means. It can ask for the volume velocity of the air in a listening point with this calculated exciting force and sound pressure / **near / which was detected by two or more sound pressure detecting means / the listening point** . Therefore, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

0018In the invention of claim 5, since the enclosure has the shape of human being's head and a thorax in addition to the operation of an invention of claim 1-4, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured.

0019In addition to an operation of an invention of claim 5, in the invention of claim 6, the sound pressure detecting means in a listening point can detect the sound pressure in the opening located in a handle part. Therefore, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured.

0020In addition to an operation of an invention of claim 1-6, in the invention of claim 7, the acoustic feature between dash panels with the input of the noise from the listening point and engine room on the sheet of the automobile vehicle interior of a room can be outputted in the form of sound pressure/volume velocity.

ExampleHereafter, the example of this invention is described. A same sign is given to drawing 8 and an identical configuration portion, it explains and the duplicate explanation is omitted.

0022Drawing 1 is a block diagram concerning the 1st example of this invention. And also in the 1st example of this invention, it has said simple point sound source 1 (drawing 8) and the same sound source 25. Although the sound source 25 is mentioned later in detail, the loudspeaker unit 11 is attached in general in the enclosure 27. The acceleration sensor 31 as a speaker cone vibration detecting means is formed in the vibration portion of the loudspeaker unit 11. The acceleration sensor 31 is connected to the arithmetic unit 21 as an acoustic feature measuring means via the amplifier 33. The microphone 35 as a sound pressure detecting means in a listening point is formed in the listening point position of the enclosure 27. The microphone 35 is connected to the arithmetic unit 21 via the amplifier 37. And said arithmetic unit 21, said acceleration sensor 31, and the microphone 35 constitute the exciting-force measuring means which measures or presumes the exciting force in a listening point in this example.

0023The details of said sound source 25 have become like drawing 2. First, the enclosure 27 is formed in the rectangle cube in the air. The bridge walls 39a, 39b, 41a, and 41b in every direction are formed in the inside of the enclosure 27. The two loudspeaker units 11 are formed in the lateral partition walls 41a and 41b. The breakthroughs 43a and 43b are formed in the top both sides of the enclosure 27. Fit fixing of the short pipes 45a and 45b is carried out to the breakthroughs 43a and 43b. The sound constitutes the openings 47a and 47b left to space from the enclosure 27 with these short pipes 45a and 45b. When the enclosure 27 is laid to the sheet 7 as mentioned above, the openings 47a and 47b are constituted so that it may become a

listening point of a crew member's ear position. Said microphone 35 is formed in the length direction central lower part of said short pipes 45a and 45b, respectively. Said loudspeaker unit 11 is being fixed to said lateral partition walls 41a and 41b, respectively. Said acceleration sensor 31 is attached to each loudspeaker unit 11, respectively. And the space 49a-49d in said enclosure 27 is filled up with the sound-absorbing materials 51a-51d.

0024Next, if the vibration applying signal from the noise source 17 is inputted into the loudspeaker unit 11 via the amplifier 19, the loudspeaker unit 11 will change a vibration applying signal into a sound, will leave this sound into the vehicle room 3 as space from the openings 47a and 47b of each short pipes 45a and 45b, and will excite the inside of the vehicle room 3. The acceleration signal of the vibration portion of the loudspeaker unit 11 at this time is detected by the acceleration sensor 31, and is inputted into the arithmetic unit 21 via the amplifier 33. The sound pressure of the sound which comes out of the openings 47a and 47b of the short pipes 45a and 45b is detected with the microphone 35, and is inputted into the arithmetic unit 21 via the amplifier 37. The sound which excited the inside of the vehicle room 3 reaches the microphone 5 of the dash panel 15, the sound pressure is detected, and the arithmetic unit 21 is inputted via the amplifier 23. And the arithmetic unit 21 calculates the exciting force of the listening point which is equivalent to an ear position using the acceleration signal from the acceleration sensor 31, and the signal (sound pressure) from the microphone 35. It asks for the volume velocity of the air of a listening point using this exciting force and the signal (sound pressure) from the microphone 35. furthermore -- using the signal from the microphone 5 of this volume velocity and the dash panel 15 -- a listening point and the dash panel 15 -- if it puts in another way, the acoustic feature between the microphone 35 and the microphone 5 can be searched for in the form of sound pressure/volume velocity.

0025Here, the volume velocity of the air of the point equivalent to an ear position is called for as follows. (1) type will be materialized if sound pressure in loudspeaker unit 11 vibration portion, sound pressure **in / respectively / for volume velocity / the position of P_A , V_A , and the microphone 35** , and volume velocity are made into P_B and V_B , respectively.

Equation 1

For drawings please refer to the original document.

Here, a, b, c, and d are values decided by shape between the loudspeaker unit 11 and the microphone 35. In this example, since the shape between the loudspeaker unit 11 and the microphone 35 does not change, it serves as a constant.

0026(1) As for the value of V_A , in a formula, the acceleration from the acceleration sensor 31 and the value of P_B are calculated for the value of P_A using the sound pressure from the microphone 35 from the voltage to a loudspeaker. Therefore, if (1) type is used, it can ask for volume velocity V_B of the air of the point equivalent to an ear position.

0027Thus, since an acoustic feature can be searched for in the form of sound pressure/volume velocity by asking for the volume velocity in a listening point in the 1st example of this invention, It is lost that the characteristic of volume velocity / loudspeaker input voltage is contained like before, and the form of an exact frequency characteristic can be searched for in accordance with the frequency characteristic of the sound pressure/volume velocity showing a actual acoustic feature.

0028Since it can ask for the volume velocity in an exciting point even if the surrounding acoustic field changes whenever it performs such processing, an acoustic feature can be searched for in the form of sound pressure/volume velocity, and measurement of an exact frequency characteristic can be realized.

0029Drawing 3 shows the block diagram concerning the 2nd example of this invention. In this example, a same sign is given to the above-mentioned example and an identical configuration portion, it explains and the duplicate explanation is omitted.

0030In this example, it differs from the 1st example in that exciting force is searched for from the input voltage of the loudspeaker unit 11, and the sound pressure of the microphone 35. Therefore, in this 2nd example, an acceleration detector is not formed in the loudspeaker unit 11, but the vibration applying signal to the loudspeaker unit 11 is inputted into the arithmetic unit 21. Namely, the arithmetic unit 21 constitutes the input detecting means to the loudspeaker unit 11 from this 2nd example, The arithmetic unit 21 as this input detecting means and the microphone 35 as a sound pressure detecting means in a listening point

constitute the exciting-force measuring means which measures or presumes the exciting force of the sound source in a listening point. And the exciting force of the sound source in a listening point can be measured from the input voltage of the loudspeaker unit 11, and the sound pressure detected with the microphone 35, and it can ask for the volume velocity in a listening point with the arithmetic unit 21 from this exciting force and the sound pressure detected with the microphone 35. The acoustic feature between the microphones 5 and 35 can be outputted in the form of sound pressure/volume velocity from this volume velocity and the sound pressure which said microphone 5 detected. Therefore, in this example, the same operation effect as the 1st example is done so, and also it is not necessary to form an acceleration sensor and a cost cut can be aimed at.

0031 Drawing 4 and drawing 5 show the 3rd example of this invention. This example is an example which the enclosure transformed. In this example, the two microphones 35a and 35b are approached and attached to the short pipes 45a and 45b, respectively. Therefore, it has composition provided with two or more sound pressure detecting means near the listening point. And the exciting force of the sound source in a listening point can be searched for with the arithmetic unit 21 from the sound pressure detected with two or more of these microphones 35a and 35b. It can ask for the volume velocity of the air in a listening point with this exciting force and the sound pressure detected with the microphones 35a and 35b. The acoustic feature between the microphone 5 and the microphone 35 can be outputted in the form of sound pressure/volume velocity using this volume velocity and the sound pressure signal detected with the microphone 5.

0032 Here, the volume velocity of the air of the point equivalent to an ear position is called for as follows. If the imaginary part of a cross spectrum **in / the distance of the two microphones 35a and 35b which approached can be kept from r , and / for the density of air / ρ and the two contiguity microphones 35a and 35b** is made into $I_m G_{AB}$ and angular frequency is set to ω , the intensity I in all the zones will become like (2) types.
Equation 2

For drawings please refer to the original document.

I can be written also like (3) types.

$I = PU$ (3)

Here, P is sound pressure and U is particle velocity.

0033 (2) The volume velocity V of air becomes like (4) types using a formula and (3) types.
Equation 3

For drawings please refer to the original document.

However, the cross-section area of a particle diameter way **in / in S / the microphones 35a and 35b**, P_A , and P_B are the detected sound pressure of the two seasonal microphones 35a and 35b.

0034 It can ask for the volume velocity of the air of the listening point which is equivalent to an ear position using the two contiguity microphones 35a and 35b as mentioned above.

0035 Therefore, the almost same operation effect as the 1st example is done so also in this 3rd example, and also it can ask for exciting force and volume velocity with the signal of the microphones 35a and 35b in a listening point, and a more exact output is attained.

0036 Drawing 6 shows the 4th example of this invention. This 4th example shows the modification of the enclosure. The enclosure 53 of this drawing 6 is equivalent to the enclosure 27 of the 1st example of said drawing 2.

Fundamental composition is the same.

However, in the example of this drawing 6, the enclosure 53 has the shape of human being's head 53a and the thorax 53b. And the opening 47a (47b) is located in the handle part 53c of the head 53a. Therefore, in this example, since the almost same operation effect as the 1st example is done so and also the enclosure 53 is carrying out shape of human being's head and a thorax, the acoustic feature in consideration of human being's head-related transfer function or the characteristic of the ear can be measured. The loudspeaker unit 11 can be attached that there is no unreasonableness in a thorax. In this 2nd example, the input voltage of the loudspeaker unit 11 can be used instead of the acceleration sensor 31, and it can also ask for

the volume velocity of the air in an ear position.

0037 Drawing 7 shows the 5th example of this invention. This example also shows the modification of the enclosure. The enclosure 55 of this drawing 7 is equivalent to the enclosure 27 of the 3rd example of said drawing 5. And the enclosure 55 has the forms of the head 55a and the thorax 55b. Therefore, the same operation effect as said 3rd example can be done so, and also there is an advantage that the acoustic feature which took into consideration human being's head-related transfer function and the characteristic of the ear like the 4th example can be measured.

0038 Although each above-mentioned example explained the case where the acoustic feature between a dash panel and the driver's seat ear position of the car interior of a room was measured, it is also possible to apply to measuring applied objects other than this, for example, the acoustic feature between the loudspeaker of an audio and a seat ear position. It is also possible to apply to applied objects other than vehicles, for example, a marine vessel, an airplane, or a house.

Problem(s) to be Solved by the Invention However, since what it is not necessarily asking for the volume velocity of the air of the point equivalent to listening points, such as a vehicle room, in the above devices, and can ask for is sound pressure / loudspeaker input voltage, The characteristic of volume velocity / loudspeaker input voltage will also be contained, the frequency characteristic of sound pressure/volume velocity and difference showing a actual acoustic feature arise, and there is a problem that the form of an exact frequency characteristic is not searched for.

0006 Then, this invention aims at offer of the acoustic feature measuring device which can measure a more exact acoustic feature easily.

Means for Solving the Problem In order to solve an aforementioned problem, an invention of claim 1, Attach a loudspeaker unit to an inside of enclosure, and to this enclosure. Provide an opening which a sound leaves to space and constitute a sound source, and said sound source is arranged so that said opening may be located in a listening point of said space, In an acoustic feature control device which arranges a sound pressure detecting means at a point with said space, and measures an acoustic feature between said listening point and a sound pressure detecting means, Whenever said sound source drives, it has an exciting-force measuring means which measures or presumes exciting force of a sound source in said listening point, and an acoustic feature measuring means which measures an acoustic feature between said listening point and a sound pressure detecting means based on said exciting force and an output signal of said sound pressure detecting means was established.

0008 An invention of claim 2 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means, It has a speaker cone vibration detecting means of said loudspeaker unit, and a sound pressure detecting means in said listening point, and consists of an arithmetic unit which calculates said exciting force based on an output signal of said speaker cone vibration detecting means and a sound pressure detecting means in said listening point.

0009 An invention of claim 3 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means, It has an input detecting means to said loudspeaker unit, and a sound pressure detecting means in said listening point, and consists of an arithmetic unit which calculates said exciting force based on an output signal of an input detecting means to said loudspeaker unit, and a sound pressure detecting means in said listening point.

0010 An invention of claim 4 is the acoustic feature measuring device according to claim 1, and said exciting-force measuring means consists of an arithmetic unit which calculates said exciting force based on an output signal of two or more sound pressure detecting means which can be set near **said** the listening point, and two or more sound pressure detecting means which can be set near **said** the listening point.

0011 An invention of claim 5 is the acoustic feature measuring device according to any one of claims 1 to 4, said enclosure has the shape of human being's head and a thorax, and said opening is located in a handle part.

0012 An invention of claim 6 is the acoustic feature measuring device according to claim 5, a sound pressure detecting means of said listening point is provided in said opening, and said

loudspeaker unit is provided in said thorax.

0013An invention of claim 7 is the acoustic feature measuring device according to any one of claims 1 to 6, formed said enclosure on a sheet of the automobile vehicle interior of a room, and provided a sound pressure detecting means arranged to said space in a dash panel of the automobile vehicle interior of a room.

Brief Description of the Drawings

Drawing 1It is the whole acoustic feature measuring device block diagram concerning the 1st example of this invention.

Drawing 2It is an expanded sectional view of the enclosure concerning the 1st example of this invention.

Drawing 3It is the whole acoustic feature measuring device block diagram concerning the 2nd example of this invention.

Drawing 4It is the whole acoustic feature measuring device block diagram concerning the 3rd example of this invention.

Drawing 5It is a sectional view of the enclosure concerning the 3rd example of this invention.

Drawing 6It is a partial sectional view of the enclosure concerning the 4th example of this invention.

Drawing 7It is a partial sectional view of the enclosure concerning the 5th example of this invention.

Drawing 8It is the whole acoustic feature measuring device block diagram concerning a conventional example.

Description of Notations

3 Vehicle room

5 Microphone

7 Sheet

11 Loudspeaker unit

21 Arithmetic unit (an acoustic feature measuring means, exciting-force measuring means)

25 Sound source

27 Enclosure

31 Acceleration sensor (exciting-force measuring means)

35 Microphone (exciting-force measuring means)

47a Opening

47b Opening

53 Enclosure

53a Head

53b Thorax

55 Enclosure

55a Head

55b Thorax

Drawing 1

For drawings please refer to the original document.

Drawing 2

For drawings please refer to the original document.

Drawing 3

For drawings please refer to the original document.

Drawing 4

For drawings please refer to the original document.

Drawing 5

For drawings please refer to the original document.

Drawing 6

For drawings please refer to the original document.

Drawing 7

For drawings please refer to the original document.

Drawing 8

For drawings please refer to the original document.

For drawings please refer to the original document.

----- Written amendment

Filing date March 14, Heisei 7

Amendment 1

Document to be Amended Specification

Item(s) to be Amended 0016

Method of Amendment Change

Proposed Amendment

0016 In the invention of claim 3, an input detecting means can detect the input to a loudspeaker unit, a sound pressure detecting means can detect the sound pressure in a listening point, and exciting force can be calculated based on the output signal of a loudspeaker input detecting means and the sound pressure detecting means in a listening point. For this reason, it can ask for the volume velocity in the sound pressure detecting means in a listening point based on the calculated exciting force and the detecting signal of the sound pressure detecting means in a listening point. For this reason, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

Amendment 2

Document to be Amended Specification

Item(s) to be Amended 0017

Method of Amendment Change

Proposed Amendment

0017 In addition to an operation of an invention of claim 1, in the invention of claim 4, two or more sound pressure detecting means which can set the sound pressure in a listening point near the listening point detect. And based on the output signal of two or more of these sound pressure detecting means, the exciting force of a listening point, i.e., the volume velocity of air, can be calculated. Therefore, the acoustic feature between a listening point and a point with

space can be outputted in the form of sound pressure/volume velocity like the invention of claim 2.

Amendment 3

Document to be AmendedSpecification

Item(s) to be Amended0024

Method of AmendmentChange

Proposed Amendment

0024Next, if the vibration applying signal from the noise source 17 is inputted into the loudspeaker unit 11 via the amplifier 19, the loudspeaker unit 11 will change a vibration applying signal into a sound, will leave this sound into the vehicle room 3 as space from the openings 47a and 47b of each short pipes 45a and 45b, and will excite the inside of the vehicle room 3. The acceleration signal of the vibration portion of the loudspeaker unit 11 at this time is detected by the acceleration sensor 31, and is inputted into the arithmetic unit 21 via the amplifier 33. The sound pressure of the sound which comes out of the openings 47a and 47b of the short pipes 45a and 45b is detected with the microphone 35, and is inputted into the arithmetic unit 21 via the amplifier 37. The sound which excited the inside of the vehicle room 3 reaches the microphone 5 of the dash panel 15, the sound pressure is detected, and the arithmetic unit 21 is inputted via the amplifier 23. And the arithmetic unit 21 calculates, the exciting force of a listening point, i.e., the volume velocity of air, which are equivalent to an ear position using the acceleration signal from the acceleration sensor 31, and the signal (sound pressure) from the microphone 35. furthermore -- using the signal from the microphone 5 of this volume velocity and the dash panel 15 -- a listening point and the dash panel 15 -- if it puts in another way, the acoustic feature between the microphone 35 and the microphone 5 can be searched for in the form of sound pressure/volume velocity.

Amendment 4

Document to be AmendedSpecification

Item(s) to be Amended0025

Method of AmendmentChange

Proposed Amendment

0025Here, the volume velocity of the air of the point equivalent to an ear position is called for as follows. (1) type will be materialized if sound pressure in loudspeaker unit 11 vibration portion, sound pressure **in / respectively / for volume velocity / the position of P_A , V_A , and the microphone 35** , and volume velocity are made into P_B and V_B , respectively.

Equation 1

For drawings please refer to the original document.

Here, a, b, c, and d are values decided by shape between the loudspeaker unit 11 and the microphone 35. In this example, since the shape between the loudspeaker unit 11 and the microphone 35 does not change, it serves as a constant.

Amendment 5

Document to be AmendedSpecification

Item(s) to be Amended0026

Method of AmendmentChange

Proposed Amendment

0026(1) As for the value of V_A , in a formula, the acceleration from the acceleration sensor 31 and the value of P_B are calculated using the sound pressure from the microphone 35. Therefore, if (1) type is used, it can ask for volume velocity V_B of the air of the point equivalent to an ear position.

Amendment 6

Document to be AmendedSpecification

Item(s) to be Amended0030

Method of AmendmentChange

Proposed Amendment

0030In this example, it differs from the 1st example in that exciting force is searched for from the input voltage of the loudspeaker unit 11, and the sound pressure of the microphone 35. Therefore, in this 2nd example, an acceleration detector is not formed in the loudspeaker unit

11, but the vibration applying signal to the loudspeaker unit 11 is inputted into the arithmetic unit 21. Namely, the arithmetic unit 21 constitutes the input detecting means to the loudspeaker unit 11 from this 2nd example, The arithmetic unit 21 as this input detecting means and the microphone 35 as a sound pressure detecting means in a listening point constitute the exciting-force measuring means which measures or presumes the exciting force of the sound source in a listening point. And the exciting force of the sound source in a listening point, i.e., the volume velocity of air, can be searched for from the input voltage of the loudspeaker unit 11, and the sound pressure detected with the microphone 35. The acoustic feature between the microphones 5 and 35 can be outputted in the form of sound pressure/volume velocity from this volume velocity and the sound pressure which said microphone 5 detected. Therefore, in this example, the same operation effect as the 1st example is done so, and also it is not necessary to form an acceleration sensor and a cost cut can be aimed at.

Amendment 7

Document to be AmendedSpecification

Item(s) to be Amended0031

Method of AmendmentChange

Proposed Amendment

0031Drawing 4 and drawing 5 show the 3rd example of this invention. This example is an example which the enclosure transformed. In this example, the two microphones 35a and 35b are approached and attached to the short pipes 45a and 45b, respectively. Therefore, it has composition provided with two or more sound pressure detecting means near the listening point. And the exciting force of the sound source in a listening point, i.e., the volume velocity of air, can be searched for with the arithmetic unit 21 from the sound pressure detected with two or more of these microphones 35a and 35b. The acoustic feature between the microphone 5 and the microphone 35 can be outputted in the form of sound pressure/volume velocity using this volume velocity and the sound pressure signal detected with the microphone 5.

Amendment 8

Document to be AmendedSpecification

Item(s) to be Amended0033

Method of AmendmentChange

Proposed Amendment

0033(2) The volume velocity V of air becomes like (4) types using a formula and (3) types.

Equation 3

For drawings please refer to the original document.

However, the cross-section area of a particle diameter way **in / in S / the microphones 35a and 35b**, $P_{A'}$ and P_B are the detected sound pressure of the two contiguity microphones 35a and 35b.

Amendment 9

Document to be AmendedSpecification

Item(s) to be Amended0035

Method of AmendmentChange

Proposed Amendment

0035Therefore, the almost same operation effect as the 1st example is done so also in this 3rd example.

Amendment 10

Document to be AmendedSpecification

Item(s) to be Amended0039

Method of AmendmentChange

Proposed Amendment

0039

Effect of the InventionAs mentioned above, according to the invention of claim 1, by an exciting-force measuring means, the exciting force of the sound source of a listening point can be measured, and the acoustic feature between a listening point and a sound pressure detecting means can be measured based on this exciting force and the output signal of the sound pressure detecting means of a point with space so that clearly. If it puts in another way,

the acoustic feature between a listening point and a sound pressure detecting means can be outputted by the relation between sound pressure/volume velocity according to exciting force, i.e., the output signal of the volume velocity of air, and a sound pressure detecting means. Therefore, since it always asks for the volume velocity in an exciting point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

Amendment 11**Document to be Amended**Specification**Item(s) to be Amended**0040**Method of Amendment**Change**Proposed Amendment**

0040In the invention of claim 2, the exciting force of the sound source in a listening point, i.e., the volume velocity of air, can be measured or presumed by the speaker cone vibration detecting means of a loudspeaker unit, and the sound pressure detecting means in a listening point. Based on this volume velocity and the output signal of the sound pressure detecting means of a point with space, the acoustic feature between a listening point and a point with space can be correctly searched for in the form of sound pressure/volume velocity. Therefore, since it can always ask for the volume velocity in an exciting point even if the surrounding acoustic field changes, an acoustic feature can be searched for correctly.

Amendment 12**Document to be Amended**Specification**Item(s) to be Amended**0041**Method of Amendment**Change**Proposed Amendment**

0041In the invention of claim 3, the volume velocity of the exciting force in a listening point, i.e., air, can be measured or presumed by the input detecting means to a loudspeaker unit, and the sound pressure detecting means in a listening point. Based on this volume velocity and the detecting signal of the sound pressure detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly. Since the input signal to a loudspeaker unit is used on the occasion of measurement or presumption of exciting force, structure can be easy and it can manufacture cheaply.

Amendment 13**Document to be Amended**Specification**Item(s) to be Amended**0042**Method of Amendment**Change**Proposed Amendment**

0042In the invention of claim 4, the exciting force of the sound source in a listening point, i.e., the volume velocity of air, can be searched for based on the output signal of two or more sound pressure detecting means which can be set to a listening point. And based on this volume velocity and the output signal of the sound pressure detecting means in a point with space, the acoustic feature between a listening point and a point with space can be outputted in the form of sound pressure/volume velocity. Therefore, even if the surrounding acoustic field changes, it can always ask for the volume velocity in an exciting point, and an acoustic feature can be searched for correctly.

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平8-159864

(43) 公開日 平成8年(1996)6月21日

(51) Int.Cl.⁶

G 0 1 H 17/00

識別記号

庁内整理番号

C

F I

技術表示箇所

審査請求 未請求 請求項の数7 O L (全 10 頁)

(21) 出願番号 特願平6-303499

(22) 出願日 平成6年(1994)12月7日

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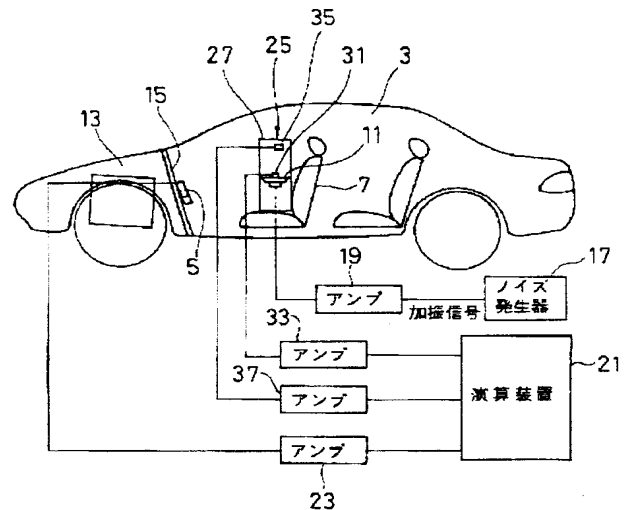
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(54) 【発明の名称】 音響特性測定装置

(57) 【要約】

【目的】 車室等を加工工作することなく車室内等の音響特性を容易かつ正確に測定することを可能とする。

【構成】 エンクロージャ27の内部にスピーカユニット11を取り付けると共に、該エンクロージャ27に、音が空間へ出てゆく開口47a、47bを設けて音源25を構成し、前記開口47a、47bが前記空間の受聴点に位置するように音源25を配置し、空間のある点に音圧検出手段5を配置し、受聴点と、音圧検出手段5との間の音響特性を測定する音響特性装置において、音源25が駆動される毎に前記受聴点における音源25の加振力を測定または推定する加振力測定手段21、31、35を有し、加振力と音圧検出手段5の出力信号とに基づいて受聴点と音圧検出手段5との間の音響特性を測定する音響特性測定手段21を設けたことを特徴とする。



【特許請求の範囲】

【請求項 1】 エンクロージャの内部にスピーカユニットを取り付けると共に、該エンクロージャに、音が空間へ出てゆく開口を設けて音源を構成し、前記開口が前記空間の受聴点に位置するように前記音源を配置し、

前記空間のある点に音圧検出手段を配置し、前記受聴点と音圧検出手段との間の音響特性を測定する音響特性測定装置において、前記音源が駆動される毎に前記受聴点における音源の加振力を測定または推定する加振力測定手段を有し、前記加振力と前記音圧検出手段の出力信号とに基づいて前記受聴点と音圧検出手段との間の音響特性を測定する音響特性測定手段を設けたことを特徴とする音響特性測定装置。

【請求項 2】 請求項 1 記載の音響特性測定装置であって、前記加振力測定手段は、前記スピーカユニットのスピーカコーン振動検出手段と、前記受聴点における音圧検出手段と、前記スピーカコーン振動検出手段及び前記受聴点における音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする音響特性測定装置。

【請求項 3】 請求項 1 記載の音響特性測定装置であって、前記加振力測定手段は、前記スピーカユニットへの入力検出手段と、前記受聴点における音圧検出手段と、前記スピーカユニットへの入力検出手段及び前記受聴点における音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする音響特性測定装置。

【請求項 4】 請求項 1 記載の音響特性測定装置であって、前記加振力測定手段は、前記受聴点近傍における複数の音圧検出手段と、前記受聴点近傍における複数の音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする音響特性測定装置。

【請求項 5】 請求項 1～4 の何れかに記載の音響特性測定装置であって、前記エンクロージャが人間の頭部と胸部の形状を有し、前記開口が耳部に位置することを特徴とする音響特性測定装置。

【請求項 6】 請求項 5 記載の音響特性測定装置であって、前記受聴点の音圧検出手段は、前記開口に設けられ、前記スピーカユニットは、前記胸部に設けられていることを特徴とする音響特性測定装置。

【請求項 7】 請求項 1～6 のいずれかに記載の音響特性測定装置であって、前記エンクロージャを自動車車室内のシート上に設け、

前記空間に配置する音圧検出手段を自動車車室内のダッシュパネルに設けたことを特徴とする音響特性測定装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 この発明は、車室等のように狭い室内における音響伝達特性を測定する音響特性測定装置に関する。

【0002】

【従来の技術】 従来のこの種の音響特性測定装置としては、例えば図 8 に示すようなものがある（特開昭 54-71675 号公報参照）。

【0003】 即ち、この音響特性測定装置は、点音源 1 を車室 3 等の空間の受聴点に配置し、マイクロホン 5 を車室 3 等の音源に相当する点に配置して上記 2 点間の音響特性を測定している。即ち、点音源 1 は、車室 3 内のシート 7 上に設置され、内部に音響制動材を充填したホーン 9 をスピーカ 11 の先に取り付けた構造となっている。これは、点音源 1 のインピーダンスを上げ、その結果周囲の音場が変わっても受聴点での体積速度の変化を少なくし、音響特性を音圧／スピーカ入力電圧の形で用いても近似的に相反性が成立するようにするためである。また、前記マイクロホン 5 はエンジンルーム 13 と車室 3 とを区画するダッシュパネル 15 に取り付けられている。そして、前記スピーカ 11 にはノイズ発生器 17 からの信号がアンプ 19 を介して入力されるようになっている。また、スピーカ入力電圧は演算装置 21 に入力されるようになっている。更に前記マイクロホン 5 の検出信号はアンプ 23 を介して演算装置 21 に入力されるようになっている。

【0004】 従ってノイズ発生器 17 からの信号がアンプ 19 を介してスピーカ 11 に入力され、放射された音はマイクロホン 5 で検出される。マイクロホン 5 の検出信号はアンプ 23 を介して演算装置 21 に入力される。従って音場における相反定理を応用し、前記 2 点間の音響特性は音圧／スピーカ入力電圧の形で表すことができ、車室等を加工、工作することなく、車室内等の音響特性を容易かつ正確に測定できる。

【0005】

【発明が解決しようとする課題】 しかしながら、上記のような装置では、車室等の受聴点に相当する点の空気の体積速度を求めているわけではなく、求めることができるのは音圧／スピーカ入力電圧であるため、体積速度／スピーカ入力電圧の特性も含まれてしまい、実際の音響特性を表す音圧／体積速度の周波数特性と違いが生じ、正確な周波数特性の形が求められないという問題がある。

【0006】 そこで、この発明は、より正確な音響特性の測定を容易に行なうことのできる音響特性測定装置の提供を目的とする。

【0007】

【課題を解決するための手段】上記課題を解決するために、請求項1の発明は、エンクロージャの内部にスピーカユニットを取り付けると共に、該エンクロージャに、音が空間へ出てゆく開口を設けて音源を構成し、前記開口が前記空間の受聴点に位置するように前記音源を配置し、前記空間のある点に音圧検出手段を配置し、前記受聴点と音圧検出手段との間の音響特性を測定する音響特性制御装置において、前記音源が駆動される毎に前記受聴点における音源の加振力を測定または推定する加振力測定手段を有し、前記加振力と前記音圧検出手段の出力信号とに基づいて前記受聴点と音圧検出手段との間の音響特性を測定する音響特性測定手段を設けたことを特徴とする。

【0008】請求項2の発明は、請求項1記載の音響特性測定装置であって、前記加振力測定手段は、前記スピーカユニットのスピーカコーン振動検出手段と、前記受聴点における音圧検出手段とを備え、前記スピーカコーン振動検出手段及び前記受聴点における音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする。

【0009】請求項3の発明は、請求項1記載の音響特性測定装置であって、前記加振力測定手段は、前記スピーカユニットへの入力検出手段と、前記受聴点における音圧検出手段とを備え、前記スピーカユニットへの入力検出手段及び前記受聴点における音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする。

【0010】請求項4の発明は、請求項1記載の音響特性測定装置であって、前記加振力測定手段は、前記受聴点近傍における複数の音圧検出手段と、前記受聴点近傍における複数の音圧検出手段の出力信号に基づいて前記加振力を演算する演算装置とからなることを特徴とする。

【0011】請求項5の発明は、請求項1～4の何れかに記載の音響特性測定装置であって、前記エンクロージャが人間の頭部と胸部の形状を有し、前記開口が耳部に位置することを特徴とする。

【0012】請求項6の発明は、請求項5記載の音響特性測定装置であって、前記受聴点の音圧検出手段は、前記開口に設けられ、前記スピーカユニットは、前記胸部に設けられていることを特徴とする。

【0013】請求項7の発明は、請求項1～6のいずれかに記載の音響特性測定装置であって、前記エンクロージャを自動車車室内のシート上に設け、前記空間に配置する音圧検出手段を自動車車室内のダッシュパネルに設けたことを特徴とする。

【0014】

【作用】上記手段の請求項1の発明によれば、スピーカユニットに入力信号があると、スピーカユニットから発

せられた音が受聴点にあるエンクロージャの開口から空間へ出ていく。空間に出た音は空間のある点に配置された音圧検出手段で検出される。そして、加振力測定手段が受聴点における音源の加振力を測定または推定する。そして、前記加振力と音圧検出手段の出力信号とに基づいて音響特性測定手段が受聴点と音圧検出手段との間の音響特性を測定する。

【0015】請求項2の発明では、請求項1の発明の作用に加え、スピーカコーン振動検出手段がスピーカユニットの振動を検出する。また、受聴点における音圧検出手段が受聴点での音圧を検出する。そして、スピーカコーン振動検出手段及び受聴点における音圧検出手段の出力信号に基づいて、スピーカユニットの加振力を演算することができる。従って、演算した加振力と受聴点における音圧検出手段の検出信号とから受聴点における音圧検出手段での空気の体積速度を求めることができる。この体積速度と空間のある点の音圧検出手段の検出信号とから、受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。

【0016】請求項3の発明では、スピーカユニットへの入力を入力検出手段が検出し、受聴点における音圧を音圧検出手段が検出し、そして、スピーカ入力検出手段及び受聴点における音圧検出手段の出力信号に基づいて加振力を演算することができる。このため、演算した加振力と受聴点における音圧検出手段の検出信号とに基づいてスピーカユニットでの体積速度を求めることができる。このため、請求項2の発明と同様に受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。

【0017】請求項4の発明では、請求項1の発明の作用に加え、受聴点での音圧を受聴点近傍における複数の音圧検出手段によって検出する。そして、この複数の音圧検出手段の出力信号に基づいてスピーカユニットの加振力を演算することができる。この演算した加振力と複数の音圧検出手段によって検出した受聴点近傍における音圧とにより受聴点での空気の体積速度を求めることができる。従って、請求項2の発明と同様に受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。

【0018】請求項5の発明では、請求項1～4の発明の作用に加え、エンクロージャが人間の頭部と胸部の形状を有しているため、人間の頭部伝達関数や耳の特性を考慮した音響特性を測定することができる。

【0019】請求項6の発明では、請求項5の発明の作用に加え、耳部に位置する開口での音圧を受聴点での音圧検出手段が検出することができる。従って、人間の頭部伝達関数や耳の特性を考慮した音響特性を測定できる。

【0020】請求項7の発明では、請求項1～6の発明の作用に加え、自動車車室内のシート上での受聴点とエ

エンジンルームからの騒音の入力があるダッシュパネルとの間の音響特性を音圧／体積速度の形で出力することができる。

【0021】

【実施例】以下、この発明の実施例を説明する。尚、図8と同一構成部分には同符号を付して説明し、また重複した説明は省略する。

【0022】図1はこの発明の第1実施例に係るブロック図である。そして、この発明の第1実施例においても前記点音源1（図8）と同様な音源25が備えられている。音源25は詳細には後述するが、概ねエンクロージャ27内にスピーカユニット11を取り付けている。スピーカユニット11の振動部にはスピーカコーン振動検出手段としての加速度センサ31が設けられている。加速度センサ31はアンプ33を介して音響特性測定手段としての演算装置21に接続されている。またエンクロージャ27の受聴点位置には受聴点における音圧検出手段としてのマイクロホン35が設けられている。マイクロホン35はアンプ37を介して演算装置21に接続されている。そして前記演算装置21と前記加速度センサ31とマイクロホン35とはこの実施例において受聴点における加振力を測定又は推定する加振力測定手段を構成している。

【0023】前記音源25の詳細は図2のようになっている。まず、エンクロージャ27は中空の矩形立方体に形成されている。エンクロージャ27の内部には縦横の仕切壁39a、39b、41a、41bが設けられている。横仕切壁41a、41bには2個のスピーカユニット11が設けられている。また、エンクロージャ27の上部両側には貫通孔43a、43bが設けられている。貫通孔43a、43bには短管45a、45bが嵌合固定されている。この短管45a、45bによってエンクロージャ27から音が空間へ出ていく開口47a、47bを構成している。開口47a、47bはエンクロージャ27を前記のようにシート7へ載置した時、乗員の耳位置の受聴点となるように構成されている。前記短管45a、45bの長さ方向中央下部には前記マイクロホン35がそれぞれ設けられている。前記横仕切壁41a、41bに前記スピーカユニット11がそれぞれ固定されている。また、各スピーカユニット11にはそれぞれ前記加速度センサ31が取り付けられている。そして、前記エンクロージャ27内の空間49a～49dには吸音材51a～51dが充填されている。

【0024】つぎに、ノイズ発生器17からの加振信号がアンプ19を介してスピーカユニット11に入力されると、スピーカユニット11は加振信号を音に変換し、この音は各短管45a、45bの開口47a、47bから空間としての車室3内へ出ていき、車室3内を加振する。この時のスピーカユニット11の振動部の加速度信号は加速度センサ31によって検出され、アンプ33を

介して演算装置21に入力される。また、短管45a、45bの開口47a、47bから出る音の音圧はマイクロホン35によって検出され、アンプ37を介して演算装置21に入力される。さらに、車室3内を加振した音はダッシュパネル15のマイクロホン5に到達してその音圧が検出され、アンプ23を介して演算装置21の入力される。そして、演算装置21は加速度センサ31からの加速度信号とマイクロホン35からの信号（音圧）を用いて耳位置に相当する受聴点の加振力を演算する。また、この加振力とマイクロホン35からの信号（音圧）を用いて受聴点の空気の体積速度を求める。さらに、この体積速度とダッシュパネル15のマイクロホン5からの信号を用いて受聴点とダッシュパネル15、換言すればマイクロホン35とマイクロホン5との間の音響特性を音圧／体積速度の形で求めることができる。

【0025】ここで、耳位置に相当する点の空気の体積速度は次のようにして求められる。スピーカユニット11振動部における音圧、体積速度をそれぞれ P_A 、 V_A 、マイクロホン35の位置における音圧、体積速度をそれぞれ P_B 、 V_B とすると（1）式が成立する。

【数1】

$$\begin{pmatrix} P_B \\ V_B \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} P_A \\ V_A \end{pmatrix} \quad (1)$$

ここで、a、b、c、dはスピーカユニット11とマイクロホン35との間の形状によって決まる値である。この実施例ではスピーカユニット11とマイクロホン35との間の形状は変わらないので定数となる。

【0026】（1）式において P_A の値はスピーカへの電圧から V_A の値は加速度センサ31からの加速度、 P_B の値はマイクロホン35からの音圧を用いて求められる。よって、（1）式を用いれば耳位置に相当する点の空気の体積速度 V_B を求めることができる。

【0027】このようにこの発明の第1実施例では、受聴点における体積速度を求めることによって音響特性を音圧／体積速度の形で求めることができるため、従来のように体積速度／スピーカ入力電圧の特性が含まれることがなくなり、実際の音響特性を表す音圧／体積速度の周波数特性と一致し、正確な周波数特性の形を求めることができる。

【0028】また、このような処理を行なうと周囲の音場が変化しても加振点での体積速度を常に求めることができるので、音圧／体積速度の形で音響特性を求めることができ、正確な周波数特性の測定を実現することができる。

【0029】図3は、この発明の第2実施例に係るブロック図を示している。この実施例において、上記実施例と同一構成部分には同符号を付して説明し、重複した説明は省略する。

【0030】この実施例ではスピーカユニット11の入力電圧とマイクロホン35の音圧とから加振力を求めている点が第1実施例と異なっている。従って、この第2実施例ではスピーカユニット11に加速度検出器は設けられておらず、スピーカユニット11への加振信号が演算装置21へ入力されるようになっている。すなわち、この第2実施例では演算装置21がスピーカユニット11への入力検出手段を構成し、この入力検出手段としての演算装置21と受聴点における音圧検出手段としてのマイクロホン35とが受聴点における音源の加振力を測定または推定する加振力測定手段を構成している。そして、スピーカユニット11の入力電圧とマイクロホン35によって検出した音圧とから受聴点における音源の加振力を測定し、この加振力とマイクロホン35によって検出した音圧とから演算装置21により受聴点における体積速度を求めることができる。さらに、この体積速度と前記マイクロホン5の検出した音圧とからマイクロホン5、35間の音響特性を音圧／体積速度の形で出力することができる。従って、この実施例では第1実施例と同様な作用効果を奏する他、加速度センサを設ける必要がなく、コストダウンを図ることができる。

【0031】図4、図5は、この発明の第3実施例を示している。この実施例はエンクロージャの変形した例である。この実施例では短管45a、45bにそれぞれ2つのマイクロホン35a、35bが近接して取り付けられている。従って、受聴点近傍に複数の音圧検出手段を*

$$V = US = - \frac{2S}{P_A + P_B} \int \frac{1}{\rho \omega \gamma} I_m G_{AB} d\omega \quad (4)$$

ただし、Sはマイクロホン35a、35bにおける粒子経路の断面積、 P_A 、 P_B は2本の季節マイクロホン35a、35bの検出音圧である。

【0034】以上のようにして、2本の近接マイクロホン35a、35bを用いて耳位置に相当する受聴点の空気の体積速度を求めることができる。

【0035】従って、この第3実施例でも第1実施例とはほぼ同様な作用効果を奏する他、受聴点でのマイクロホン35a、35bの信号によって加振力及び体積速度を求めることができ、より正確な出力が可能となる。

【0036】図6は、この発明の第4実施例を示している。この第4実施例はエンクロージャの変形例を示している。この図6のエンクロージャ53は、前記図2の第1実施例のエンクロージャ27に対応しており、基本的な構成は同一である。ただし、この図6の実施例ではエンクロージャ53が人間の頭部53aと胸部53bの形状を有したものである。そして、頭部53aの耳部53cに開口47a（47b）を位置させたものである。従って、この実施例では第1実施例とはほぼ同様な作用効果を奏する他、エンクロージャ53が人間の頭部と胸部の形状をしているため、人間の頭部伝達関数や耳の特性を

*備えた構成となっている。そして、この複数のマイクロホン35a、35bで検出した音圧から演算装置21によって受聴点での音源の加振力を求めることができるのである。また、この加振力とマイクロホン35a、35bで検出した音圧とによって受聴点での空気の体積速度を求めることができる。更に、この体積速度とマイクロホン5で検出した音圧信号とを用いてマイクロホン5とマイクロホン35との間の音響特性を音圧／体積速度の形で出力することができる。

【0032】ここで、耳位置に相当する点の空気の体積速度は次のようにして求められる。2本の近接したマイクロホン35a、35bの距離をr、空気の密度を ρ 、2本の近接マイクロホン35a、35bにおけるクロススペクトルの虚部を $I_m G_{AB}$ 、角振動数を ω とすると全帯域でのインテンシティIは（2）式のようになる。

【数2】

$$I = \int - \frac{1}{\rho \omega \gamma} I_m G_{AB} d\omega \quad (2)$$

また、Iは（3）式のようにも書ける。

$$I = PU \quad (3)$$

ここで、Pは音圧、Uは粒子速度である。

【0033】（2）式、（3）式を用いて空気の体積速度Vは、（4）式のようになる。

【数3】

考慮した音響特性を測定することができる。また、スピーカユニット11を胸部に無理なく取り付けすることができる。なお、この第2実施例において加速度センサ31の代わりにスピーカユニット11の入力電圧を用いて耳位置における空気の体積速度を求めることもできる。

【0037】図7は、この発明の第5実施例を示している。この実施例もエンクロージャの変形例を示している。この図7のエンクロージャ55は、前記図5の第3実施例のエンクロージャ27に対応している。そして、エンクロージャ55が頭部55aと胸部55bの形を有したものである。従って、前記第3実施例と同様な作用効果を奏することができる他、第4実施例と同様に人間の頭部伝達関数や耳の特性を考慮した音響特性を測定できるという利点がある。

【0038】なお、上記各実施例ではダッシュパネルと車室内の運転席耳位置との間の音響特性を測定する場合について説明したが、これ以外の適用対象、例えばオーディオのスピーカと座席耳位置との間の音響特性を測定することに応用することも可能である。また、車両以外の適用対象、例えば船舶、航空機、あるいは家屋等に適用することも可能である。

【0039】

【発明の効果】以上より明らかなように、請求項1の発明によれば、加振力測定手段によって、受聴点の音源の加振力を測定し、この加振力と空間のある点の音圧検出手段の出力信号とに基づいて受聴点と音圧検出手段との間の音響特性を測定することができる。即ち、加振力に基づいて受聴点における体積速度を求め、この体積速度と音圧検出手段との出力信号とにより受聴点と音圧検出手段との間の音響特性を音圧／体積速度の関係で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めるため、音響特性を正確に求めることができる。

【0040】請求項2の発明では、スピーカユニットのスピーカコーン振動検出手段と受聴点における音圧検出手段とにより受聴点における音源の加振力を測定または推定することができる。そして、この加振力と受聴点における音圧検出手段の出力信号とに基づいて受聴点の体積速度を求めることができる。この体積速度と空間のある点の音圧検出手段の出力信号とに基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で正確に求めることができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができるので、音響特性を正確に求めることができる。

【0041】請求項3の発明では、スピーカユニットへの入力検出手段と受聴点における音圧検出手段とにより、受聴点における加振力を測定または推定することができる。そして、この加振力と受聴点における音圧検出手段の出力信号とに基づいて受聴点での空気の体積速度を求めることができる。この体積速度と空間のある点での音圧検出手段の検出信号とに基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができ、音響特性を正確に求めることができる。また、加振力の測定または推定に際してスピーカユニットへの入力信号を用いるため、構造が簡単で安価に製造することができる。

【0042】請求項4の発明では、受聴点における複数の音圧検出手段の出力信号に基づいて受聴点における音源の加振力を求めることができる。この加振力と受聴点での音圧検出手段の出力信号とに基づいて受聴点での体積速度を求めることができる。そして、この体積速度と空間のある点での音圧検出手段の出力信号とに基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができ、音響特性を正確に求めることができる。また、受聴点での複数の音圧検出手段の信号によって加振力を求めるため、より正確な音響特性の出力を行なうことができる。

【0043】請求項5の発明では、請求項1～4のいずれかの発明の効果に加え、人間の頭部伝達関数や耳の特性を考慮して音響特性を測定することができ、人間にとってより正確な音響特性を測定することができる。

【0044】請求項6の発明では、請求項5の発明の効果に加え、受聴点の音圧検出手段を耳部の開口に設けることができ、より正確に音響特性を出力することができる。また、スピーカユニットを胸部に設けることによってスピーカユニットの設定を無理なく行なうことができる。

【0045】請求項7の発明では、請求項1～6のいずれかの発明の効果に加え、自動車車室内のシートからダッシュパネルの間の音響特性を正確に求めることができる。

【図面の簡単な説明】

【図1】この発明の第1実施例に係る音響特性測定装置の全体ブロック図である。

【図2】この発明の第1実施例に係るエンクロージャの拡大断面図である。

【図3】この発明の第2実施例に係る音響特性測定装置の全体ブロック図である。

【図4】この発明の第3実施例に係る音響特性測定装置の全体ブロック図である。

【図5】この発明の第3実施例に係るエンクロージャの断面図である。

【図6】この発明の第4実施例に係るエンクロージャの一部断面図である。

【図7】この発明の第5実施例に係るエンクロージャの一部断面図である。

【図8】従来例に係る音響特性測定装置の全体ブロック図である。

【符号の説明】

3 車室

5 マイクロホン

7 シート

11 スピーカユニット

21 演算装置（音響特性測定手段、加振力測定手段）

25 音源

27 エンクロージャ

31 加速度センサ（加振力測定手段）

35 マイクロホン（加振力測定手段）

47 a 開口

47 b 開口

53 エンクロージャ

53 a 頭部

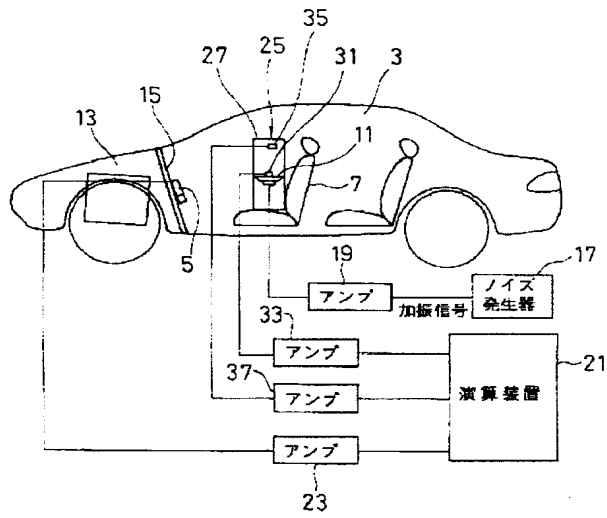
53 b 胸部

55 エンクロージャ

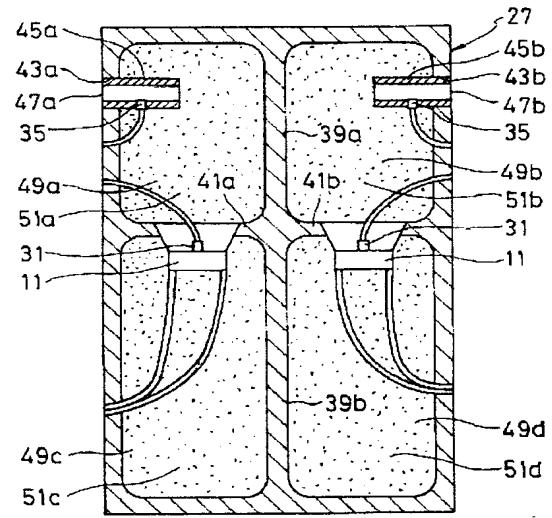
55 a 頭部

55 b 胸部

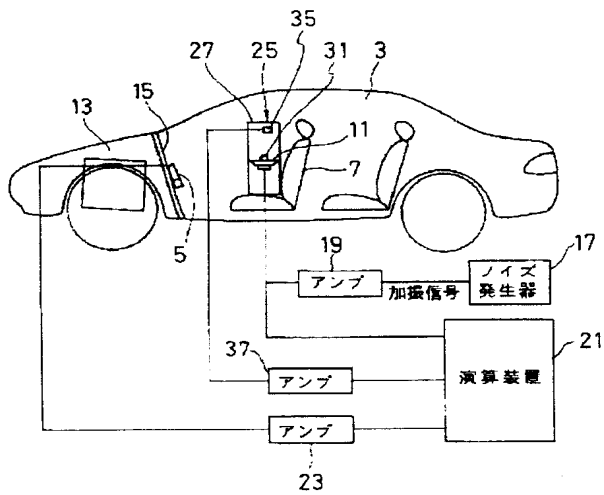
【図1】



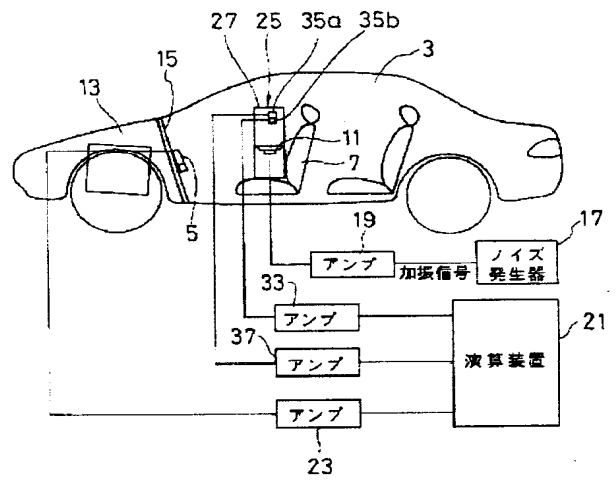
【図2】



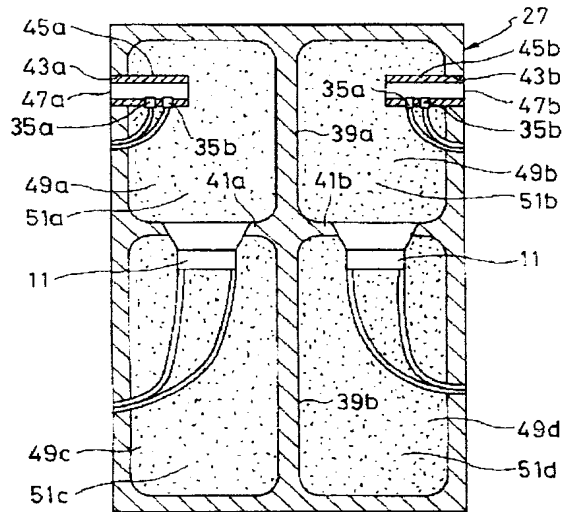
【図3】



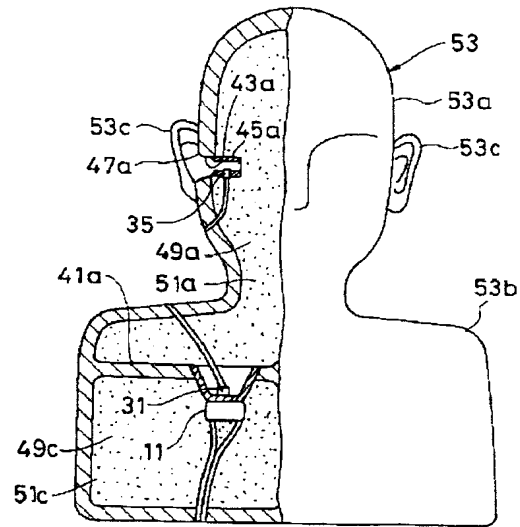
【図4】



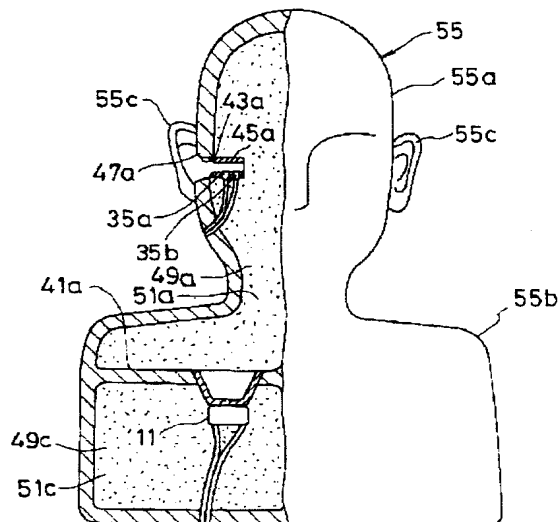
【図 5】



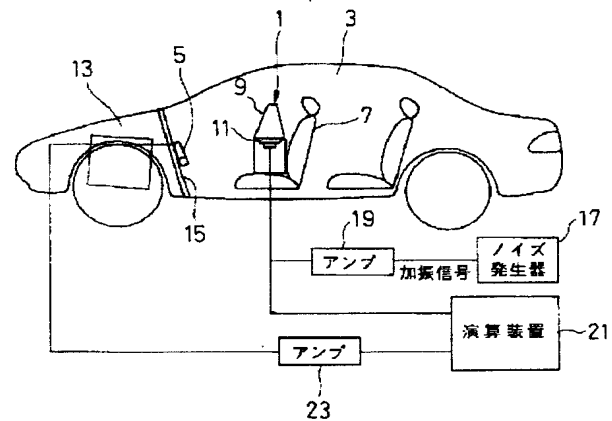
【図 6】



【図 7】



【図 8】



【手続補正書】

【提出日】平成 7 年 3 月 1 4 日

【手続補正 1】

【補正対象書類名】明細書

【補正対象項目名】0 0 1 6

【補正方法】変更

【補正内容】

【0 0 1 6】請求項 3 の発明では、スピーカユニットへ

の入力を入力検出手段が検出し、受聴点における音圧を音圧検出手段が検出し、そして、スピーカ入力検出手段及び受聴点における音圧検出手段の出力信号に基づいて加振力を演算することができる。このため、演算した加振力と受聴点における音圧検出手段の検出信号とに基づいて受聴点における音圧検出手段での体積速度を求めることができる。このため、請求項 2 の発明と同様に受聴

点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。

【手続補正 2】

【補正対象書類名】明細書

【補正対象項目名】0017

【補正方法】変更

【補正内容】

【0017】請求項 4 の発明では、請求項 1 の発明の作用に加え、受聴点での音圧を受聴点近傍における複数の音圧検出手段によって検出する。そして、この複数の音圧検出手段の出力信号に基づいて受聴点の加振力すなわち空気の体積速度を演算することができる。従って、請求項 2 の発明と同様に受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。

【手続補正 3】

【補正対象書類名】明細書

【補正対象項目名】0024

【補正方法】変更

【補正内容】

【0024】つぎに、ノイズ発生器 17 からの加振信号がアンプ 19 を介してスピーカユニット 11 に入力されると、スピーカユニット 11 は加振信号を音に変換し、この音は各短管 45 a、45 b の開口 47 a、47 b から空間としての車室 3 内へ出ていき、車室 3 内を加振する。この時のスピーカユニット 11 の振動部の加速度信号は加速度センサ 31 によって検出され、アンプ 33 を介して演算装置 21 に入力される。また、短管 45 a、45 b の開口 47 a、47 b から出る音の音圧はマイクロホン 35 によって検出され、アンプ 37 を介して演算装置 21 に入力される。さらに、車室 3 内を加振した音はダッシュパネル 15 のマイクロホン 5 に到達してその音圧が検出され、アンプ 23 を介して演算装置 21 の入力される。そして、演算装置 21 は加速度センサ 31 からの加速度信号とマイクロホン 35 からの信号（音圧）を用いて耳位置に相当する受聴点の加振力すなわち空気の体積速度を演算する。さらに、この体積速度とダッシュパネル 15 のマイクロホン 5 からの信号を用いて受聴点とダッシュパネル 15、換言すればマイクロホン 35 とマイクロホン 5 との間の音響特性を音圧／体積速度の形で求めることができる。

【手続補正 4】

【補正対象書類名】明細書

【補正対象項目名】0025

【補正方法】変更

【補正内容】

【0025】ここで、耳位置に相当する点の空気の体積速度は次のようにして求められる。スピーカユニット 11 振動部における音圧、体積速度をそれぞれ P_A 、 V_A 、マイクロホン 35 の位置における音圧、体積速度をそれぞれ P_B 、 V_B とすると（1）式が成立する。

【数 1】

$$\begin{pmatrix} P_B \\ V_B \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} P_A \\ V_A \end{pmatrix} \quad (1)$$

ここで、 a 、 b 、 c 、 d はスピーカユニット 11 とマイクロホン 35 との間の形状によって決まる値である。この実施例ではスピーカユニット 11 とマイクロホン 35 との間の形状は変わらないので定数となる。

【手続補正 5】

【補正対象書類名】明細書

【補正対象項目名】0026

【補正方法】変更

【補正内容】

【0026】（1）式において V_A の値は加速度センサ 31 からの加速度、 P_B の値はマイクロホン 35 からの音圧を用いて求められる。よって、（1）式を用いれば耳位置に相当する点の空気の体積速度 V_B を求めることができる。

【手続補正 6】

【補正対象書類名】明細書

【補正対象項目名】0030

【補正方法】変更

【補正内容】

【0030】この実施例ではスピーカユニット 11 の入力電圧とマイクロホン 35 の音圧とから加振力を求めている点が第 1 実施例と異なっている。従って、この第 2 実施例ではスピーカユニット 11 に加速度検出器は設けられておらず、スピーカユニット 11 への加振信号が演算装置 21 へ入力されるようになっている。すなわち、この第 2 実施例では演算装置 21 がスピーカユニット 11 への入力検出手段を構成し、この入力検出手段としての演算装置 21 と受聴点における音圧検出手段としてのマイクロホン 35 とが受聴点における音源の加振力を測定または推定する加振力測定手段を構成している。そして、スピーカユニット 11 の入力電圧とマイクロホン 35 によって検出した音圧とから受聴点における音源の加振力、すなわち空気の体積速度を求めることができる。さらに、この体積速度と前記マイクロホン 5 の検出した音圧とからマイクロホン 5、35 間の音響特性を音圧／体積速度の形で出力することができる。従って、この実施例では第 1 実施例と同様な作用効果を奏する他、加速度センサを設ける必要がなく、コストダウンを図ることができる。

【手続補正 7】

【補正対象書類名】明細書

【補正対象項目名】0031

【補正方法】変更

【補正内容】

【0031】図4、図5は、この発明の第3実施例を示している。この実施例はエンクロージャの変形した例である。この実施例では短管45a、45bにそれぞれ2つのマイクロホン35a、35bが近接して取り付けられている。従って、受聴点近傍に複数の音圧検出手段を備えた構成となっている。そして、この複数のマイクロホン35a、35bで検出した音圧から演算装置21によって受聴点での音源の加振力、すなわち空気の体積速度を求めることができるのである。更に、この体積速度とマイクロホン5で検出した音圧信号とを用いてマイクロホン5とマイクロホン35との間の音響特性を音圧／＊

$$V = US = - \frac{2S}{P_A + P_B} \int \frac{1}{\rho \omega \gamma} I_m G_{AB} d\omega \quad (4)$$

ただし、Sはマイクロホン35a、35bにおける粒子経路の断面積、 P_A 、 P_B は2本の近接マイクロホン35a、35bの検出音圧である。

【手続補正9】

【補正対象書類名】明細書

【補正対象項目名】0035

【補正方法】変更

【補正内容】

【0035】従って、この第3実施例でも第1実施例とほぼ同様な作用効果を奏する。

【手続補正10】

【補正対象書類名】明細書

【補正対象項目名】0039

【補正方法】変更

【補正内容】

【0039】

【発明の効果】以上より明らかなように、請求項1の発明によれば、加振力測定手段によって、受聴点の音源の加振力を測定し、この加振力と空間のある点の音圧検出手段の出力信号とに基づいて受聴点と音圧検出手段との間の音響特性を測定することができる。換言すれば、加振力、すなわち空気の体積速度と音圧検出手段との出力信号とにより受聴点と音圧検出手段との間の音響特性を音圧／体積速度の関係で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めるため、音響特性を正確に求めることができる。

【手続補正11】

【補正対象書類名】明細書

【補正対象項目名】0040

【補正方法】変更

【補正内容】

【0040】請求項2の発明では、スピーカユニットのスピーカコーン振動検出手段と受聴点における音圧検出手段とにより受聴点における音源の加振力、すなわち空気の体積速度を測定または推定することができる。この体積速度と空間のある点の音圧検出手段の出力信号とに

＊体積速度の形で出力することができる。

【手続補正8】

【補正対象書類名】明細書

【補正対象項目名】0033

【補正方法】変更

【補正内容】

【0033】(2)式、(3)式を用いて空気の体積速度Vは、(4)式のようになる。

【数3】

基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で正確に求めることができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができるので、音響特性を正確に求めることができる。

【手続補正12】

【補正対象書類名】明細書

【補正対象項目名】0041

【補正方法】変更

【補正内容】

【0041】請求項3の発明では、スピーカユニットへの入力検出手段と受聴点における音圧検出手段とにより、受聴点における加振力、すなわち空気の体積速度を測定または推定することができる。この体積速度と空間のある点での音圧検出手段の検出信号とに基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができ、音響特性を正確に求めることができる。また、加振力の測定または推定に際してスピーカユニットへの入力信号を用いるため、構造が簡単で安価に製造することができる。

【手続補正13】

【補正対象書類名】明細書

【補正対象項目名】0042

【補正方法】変更

【補正内容】

【0042】請求項4の発明では、受聴点における複数の音圧検出手段の出力信号に基づいて受聴点における音源の加振力、すなわち空気の体積速度を求めることができる。そして、この体積速度と空間のある点での音圧検出手段の出力信号とに基づいて受聴点と空間のある点との間の音響特性を音圧／体積速度の形で出力することができる。従って、周囲の音場が変化しても加振点での体積速度を常に求めることができ、音響特性を正確に求めることができる。